



INVESTIGATOR'S ANNUAL REPORT

United States Department of the Interior
National Park Service

All or some of the information you provide may become available to the public.

OMB # (1024-0236)
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Reporting Year: 2010	Park: Shenandoah NP	Select the type of permit this report addresses: Scientific Study	
Name of principal investigator or responsible official: Rebecca Forkner		Office Phone: (703) 993-4683	
Mailing address: Environmental Science & Policy, MSN 5F2 George Mason University 4400 University Drive Fairfax, VA 22030 USA		Office FAX Office Email rforkner@gmu.edu	
Additional investigators or key field assistants (first name, last name, office phone, office email) No co-investigators			
Project Title (maximum 300 characters): Phenological Changes in Insects and Plant Phenolics Along Altitude Gradients			
Park-assigned Study or Activity #: SHEN-00355	Park-assigned Permit #: SHEN-2008-SCI-0016	Permit Start Date: Jul 17, 2008	Permit Expiration Date: Dec 31, 2011
Scientific Study Starting Date: Jul 17, 2008		Estimated Scientific Study Ending Date: Dec 31, 2038	
For either a Scientific Study or a Science Education Activity, the status is: Continuing		For a Scientific Study that is completed, please check each of the following that applies: <input type="checkbox"/> A final report has been provided to the park or will be provided to the park within the next two years <input type="checkbox"/> Copies of field notes, data files, photos, or other study records, as agreed, have been provided to the park <input type="checkbox"/> All collected and retained specimens have been cataloged into the NPS catalog system and NPS has processed loan agreements as needed	
Activity Type: Research			
Subject/Discipline: Plant Communities (Vegetation)			

Purpose of Scientific Study or Science Education Activity during the reporting year (maximum 4000 characters):

Phenological research indicates that cumulative temperature before leaf fall explains less than 50% of autumn foliar color change, and temperature alone is not sufficient to forecast the onset of leaf coloring. The goal of our on-going project is to determine the role that insects play in altering both the timing of leaf loss and the amount and vibrancy of anthocyanin (red) coloration in autumn leaves for common Eastern U.S. deciduous trees.

Findings and status of Scientific Study or accomplishments of Science Education Activity during the reporting year (maximum 4000 characters):

We collected data on herbivory, autumn leaf coloration, and end of season leaf abscission for *Acer rubrum* (red maple) trees from forested stands within the Shenandoah National Park at elevations from 1,800 to 3,300 ft (from Fox Hollow Trail at mile marker 4 to

sites along Browntown trail and Elkwallow at mile marker 24) as a part of a larger study on the role of insect damage and climate change on leaf phenology in Eastern deciduous forests. We collected additional data on phenology at field sites at mid-elevations within the National Zoological Park Conservation Research Center (CRC) in Front Royal, VA and at low elevations within the Bull Run â Occoquan Regional Park Watershed in Fairfax County, VA. We predicted that herbivory by native insects would increase amounts of anthocyanin pigment compounds responsible for red coloration in autumn leaves and advance the timing of autumn leaf abscission.

The timing of end of season leaf abscission in *A. rubrum* was significantly, positively correlated with herbivory, measured as percent leaf area removed (LAR, $r^2 = 0.12$, $P = 0.0034$). As LAR for individual red maple trees increased, trees dropped leaves earlier in October. In addition, there was a trend for herbivory to increase with elevation: LAR was nearly two times higher at sites above 2000 feet compared to lower elevation locations (23% in site above 2000 ft vs. 11% in sites below 2000 ft).

Contrary to predictions, there was a trend in 2010 for a decline with increasing elevation in the percent of autumn leaves showing anthocyanin pigmentation (i.e., red color) at peak color change. We expected that high elevation trees would show greater amounts of red pigmentation and more brilliant color displays because herbivory should increase plant investment in these chemical compounds. However, cumulative seasonal rainfall was low in 2010, and *A. rubrum* trees within the Shenandoah National Park experienced significant drought stress. Leaves showed carotenoid (yellow) rather than anthocyanin (red) pigmentation as leaf coloration took place earlier in the season in response to water stress and before up-regulation of autumn anthocyanin production in *A. rubrum*. In addition, the lower percentages of leaves showing color change at high elevations did not indicate that these sites did not show autumn foliar pigmentation, but that trees did not retain pigmented leaves but abscised yellow leaves at early, discontinuous intervals due to drought stress.

In combination with an increase in herbivory with elevation and an increase in leaf abscission in response to herbivory, lower tolerance to drought will negatively impact foliar color displays for forests within the Shenandoah National Park. Specifically, sites above 2000 ft (e.g., Matthews Arm campground) will be at greater risk of shortened, muted color displays. The data collected over the last 3 years on this permit has contributed to an NSF proposal seeking federal funding for a larger, experimental investigation of the links between autumn pigmentation, herbivory, and climate change. Research in subsequent years will include an assessment of the links between autumn and spring plant phenologies and a comparison of autumn color displays in trees within areas repeatedly defoliated by gypsy moths.

For Scientific Studies (not Science Education Activities), were any specimens collected and removed from the park but not destroyed during analysis? No	
Funding specifically used in this park this reporting year that was provided by NPS (enter dollar amount): \$0	Funding specifically used in this park this reporting year that was provided by all other sources (enter dollar amount): \$0
List any other U.S. Government Agencies supporting this study or activity and the funding each provided this reporting year: 	

Paperwork Reduction Act Statement: A federal agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a valid OMB control number. Public reporting for this collection of information is estimated to average 1.625 hours per response, including the time for reviewing instructions, gathering and maintaining data, and completing and reviewing the forms. Direct comments regarding this burden estimate or any aspect of this form to Dr. John G. Dennis, Natural Resources (3127 MIB), National Park Service, 1849 C Street, N.W., Washington, DC 20240.
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